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Conceptual Editorial

Potential of Industrial Food-Waste Sources for Value Addition

Food waste (FW) is one of the abundantly available organic wastes produced from the activities of food production including food processing plants, domestic and commercial kitchens (cafeterias and restaurants). FAO in 2017 estimated that, nearly 1.3×10^9 tonnes of foods including fresh vegetables, fruits, meat, and bakery and dairy products are lost along the food supply chain. The amount of food waste is projected to increase in the coming years due to population growth and scarcity of food storage places, mainly in Asian countries. For example, the annual amount of urban FW in Asian countries increasing from 278 to 416 million tonnes from 2005 to 2020. Cereals, pulses, grains, milk and dairy products, vegetables and fruits are the typical foods wasted in Asia. The management (disposal and treatment) of food waste is very important because the uncontrolled decomposition of it produce green house gasses that contribute to global warming. It is also often expensive to transport and handle food waste, thus enhancing the economic advantage of onsite treatment. The potential of the valorization of the food waste depends on the available information on their valuable and transformable components (Fig. 1). Currently converting them into valuable products like biofuels, platform chemicals and purification of functional molecules are the best suitable options in the available food waste management practices.

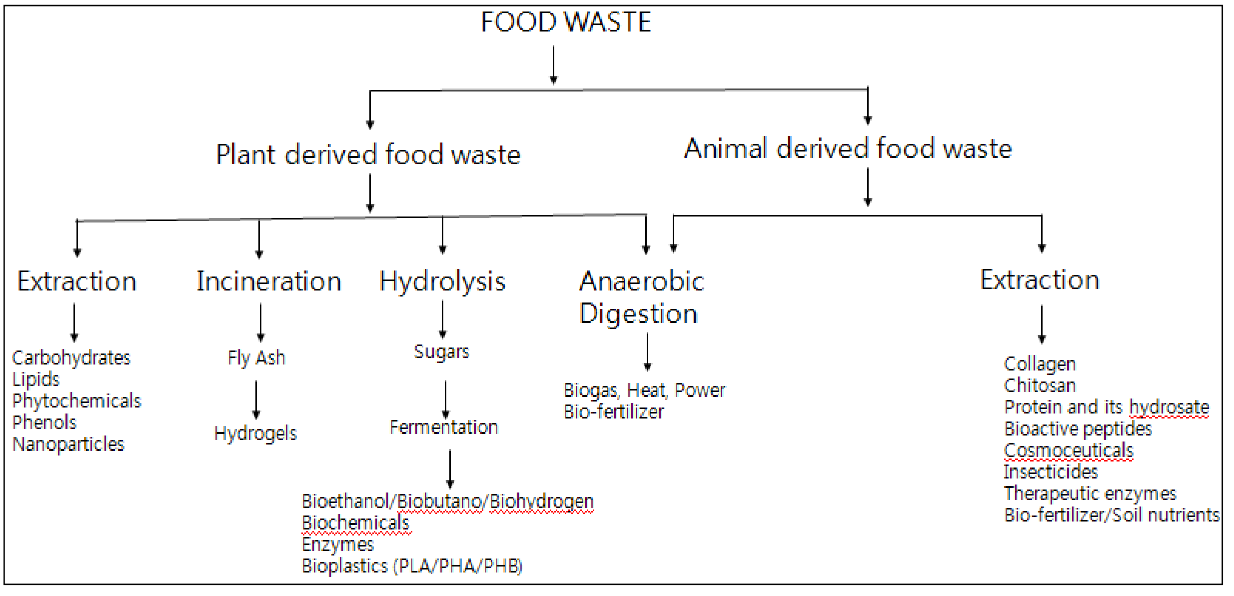

Fig. 1

Bioethanol can be produced from cellulose and starch rich sources, for example, potato, rice, and sugar cane. Starch can be easily converted to glucose by commercial enzymes and sub-sequently fermented to ethanol particularly by *Saccharomyces cerevisiae*. At the same time the hydrolysis of cellulose is more difficult and FW hydrolysis becomes much harder if large quantities of lignocellulosic feedstocks are present in FW. Lignocellulosic materials can be hydrolysed and convert to simple sugars by using physical, chemical and biological processes. Physical and chemical processes use environmentally hazardous concentrated acid, alkali, peroxide, ozone, ammonia at high pressure and temperatures. Hence, the biological process, by using enzymes is sustainable and environmental friendly. Sequential and mixed culturing methods are very advantageous for consolidated bioprocessing (CBP) where hydrolysis and product production processed combined and simultaneously occur. This is potential for economical biofuel production because it avoid the costly enzymes usage. The production of biogas, particularly methane *via* anaerobic processes, is an accept-able solution for waste management because of its low cost, low production of residual waste, and its utilization as a renewable energy source. Biodiesel can also be produced from FW by the transesterification waste oils by the microbial lipases. In addition to this microbial oils can be produced by many yeast strains, *A. niger* and Chorella can grow using FW as feedstock and from it we can extract oil and pigments. FW rich in carbohydrates is well suitable feedstock for H_2 production. Recent studies on H_2 production from FW are providing attractive yields ranged from 0.9 mol H_2/mol hexose to 8.35 mol H_2/mol hexose and during the production factors such as the composition of FW, pretreatments, and process configurations may affect H_2yields. Hydrogen production by Chlorella is very promising due to easy growth using wastewater from food industry and sun light. In other way, suitability of molasses, Napier grass (*Pennisetum purpureum*), empty fruit bunches (EFB), palm oilmill effluent (POME), and glycerol waste as a co-substrate with biomass for biohythane production was successful.

Apple pomace can be convert to ethanol through dilute acid and enzyme hydrolysis processes and produced 200 g/l ethanol from one kilogram dried biomass. Apple pomace also utilized for many other valuable products like micobioal enzymes (*Pectine esterases*), high crude protein along with ethanol and microbial natural colours (red, yellow, orange and black) through solid-state fermentation (SSF). The intake of apple pomace was shown to beneficially influence digesting enzymes, intestinal microbiome, and plasma cholesterol and triglyceride levels. Hence, it could play an important role in the prevention of lifestyle diseases such as type-2 diabetes, hypercholesterolemia, and hyperglyceridemia. Cereal waste, rice bran, wheat bran, husk, sesame cake, oat milling waste and brewers spent grain have been utilized for the producton of vauable products such as ethanol, butanol, enzymes and extracted functional molecules like fructans, antioxidants, ferulic acid and fibre. With advancement of science and technology, many valuable products are producing from FW especially from fruit and vegetable waste (antioxidants, biocolours, pigments, pretein, oligosaccharides) including the bulk products (ethanol, butanol, lactic acid, citric acid, microbial enzymes and biogas) economically and sustainably through biorefinery process. Platform chemicals are the main feedstock for producing industrial fine chemicals, chemical intermediates, and final products. For example, succinic and lactic acids are used as starting materials for the production of pyrolidones and bioplastics, respectively. At present the majority of the platform chemicals are produced from petroleum refining. In recent days biological production from renewable resources is gaining interest due to the dwindling of oil reserves, increasing prices, and environmental concerns. Biological production of platform chemicals from agricultural products, lignocellulosic materials, and waste biomass has been reported. Food waste is posing a global challenge due to its large vol-ume and unstable nature. Therefore, the valorization of food waste is gaining more and more interest.

The critical stage of biomass bioconversion is saccharification, which hampers its commercial use. Hence, there is an increasing interest on the production of biomass saccharifying enzymes, mainly amylases and cellulases. There are number of publications on the lab scale production of microbial enzymes having industrial importance such as proteases, amylases, lignocellulosic enzymes, and lipases using different types of FW. Currently we are working on evaluating the different FW substances for their suitability in the form of composition and availability and ease of fermentation. We have utilized the industrial mango waste for the production of ethanol and lactic acid and successfully produced 7.5% w/v ethanol and 11%w/v lactic acid. The dried mango peel powder containing very high sugar concentration (25-35% w/w) when compared to may fruit peels and at the same time the mango kernel has 50-60% w/w of starch which can be convert to fuels and platform chemicals. Hydrolysis of complex carbohydrate components of FW to high concentrations of oligosaccharides and monosaccharides is very important in fermentation of valuable products.

Synthesis and production of nanomaterials from food processing residue is a new area of research. In recent years rice bran, husk and wheat husk have been used as potential components to produce nanoparticles. Biopolymers such as xylan, cellulose, starch, and chitosan are widely using in synthesis of stable nanoparticles. Nanoparticles exhibiting antibacterial activity were developed using a cost-effective approach and showing significant inhibitory activity at as low as 25 mg/ml and nanosilica prepared from rice husk were found to be effective in the removal of organic dyes. Animal derived food waste is very valuable and using in extracting of wide range of byproducts like, chitosan, collagen, therapeutic enzymes, protein hydrolysates and functional peptides. The utilization of animal waste for value addition will avoid environmental pollution and provide economic benefits to the processing industry.

In future, success food waste value addition innovations will depend on high yielding pretreatment and saccharification methods, which also produce low quantities of ptreatment inhibitors. It is required to focus on techniques that improve of for the hydrolysis of lignocellulosic biomass and it results in higher sugar yields. Enzymatic hydrolysis requires further improvements especially in the terms of enzyme separation and reutilization after biomass treatment. Also, the complete characterization of the agro-industrial byproducts is required, in which it could be useful for the production of new microbial valorized products. Processing of food waste through Biorefinery is beneficial because it separates all the value added products from the feedstock, with little or no waste. This will lower the total environmental impact, besides improving the economics so that these processes can contend with the petrochemical industry. It is also very essential to improve the rate of enzymatic hydrolysis by production robust enzymes through rDNA technology. It is also essential to take help of the genetically modified microorganisms (GMOs) to ferment C_5 sugars from hemi-cellulose, which is not normally assimilated by the natural microbial strains.

L. Veeranjaneya Reddy

Department of Microbiology, Yogi Vemana University, Kadapa, Andhra Pradesh, India